

CLAIMS

What is claimed is:

- 1 1. In a charge pump having first and second flying
2 capacitors and providing a regulated charge pump output, a
3 method of pumping charge comprising:
4 providing a first signal responsive to the difference
5 between a feedback signal from the charge pump output and a
6 reference; and,
7 alternately switching between:
8 a) coupling the first flying capacitor between
9 first and second power supply terminals, and coupling
10 the second flying capacitor between the first signal and
11 the charge pump output; and,
12 b) coupling the second flying capacitor between
13 first and second power supply terminals, and coupling
14 the first flying capacitor between the first signal and
15 the charge pump output;
16 the charge pump output, the first signal and the voltage
17 on the flying capacitor coupled between the first signal and
18 the charge pump output forming a continuous linear regulation
19 loop.

1 2. The method of claim 1 wherein the first signal is
2 provided by an amplifier, and the switching is done before
3 the amplifier saturates.

1 3. The method of claim 2 wherein the switching occurs
2 when the output of the amplifier reaches a voltage a
3 predetermined increment away from saturation.

1 4. The method of claim 2 wherein the switching is done
2 when the output of the amplifier reaches a predetermined
3 voltage.

1 5. The method of claim 4 wherein the output of the
2 amplifier is compared with a second reference, and wherein
3 the switching is controlled by the complimentary change of
4 state of a circuit triggered by a pulse resulting from a
5 predetermined change of state of the comparison.

1 6. The method of claim 4 further comprising starting
2 the charge pump by forcing the switching to occur.

1 7. The method of claim 4 further comprising starting
2 the charge pump by forcing the switching to occur at the
3 maximum rate the charge pump will operate.

1 8. The method of claim 4 further comprising starting
2 the charge pump by forcing the switching to occur at any rate
3 up to the maximum rate the switching may be accomplished.

1 9. The method of claim 2 wherein the amplifier is a
2 differential amplifier and one input to the differential
3 amplifier is coupled to a reference voltage.

1 10. The method of claim 1 wherein the reference voltage
2 is a power supply voltage.

1 11. The method of claim 1 wherein the reference voltage
2 is proportional to a power supply voltage.

1 12. The method of claim 1 wherein the switching occurs
2 at a fixed frequency.

1 13. The method of claim 1 wherein the feedback signal
2 is obtained from a voltage divider coupled between the charge
3 pump output and the first power supply terminal.

1 14. The method of claim 1 wherein the feedback signal
2 is obtained by level shifting the charge pump output.

1 15. A charge pump comprising: ~
2 first and second flying capacitors;
3 an amplifier;

4 a plurality of switches;
5 the amplifier being coupled to provide an output
6 responsive to the difference between a voltage responsive to
7 an output voltage of the charge pump and a reference;
8 the switches being coupled to alternately switch
9 between:

10 a) coupling the first flying capacitor between
11 first and second power supply terminals, and coupling
12 the second flying capacitor between the amplifier output
13 and the charge pump output; and,

14 b) coupling the second flying capacitor between
15 first and second power supply terminals, and coupling
16 the first flying capacitor between the amplifier output
17 and the charge pump output.

1 16. The charge pump of claim 15 further comprised of
2 switch control circuitry causing the alternating switching
3 before the amplifier reaches saturation.

1 17. The charge pump of claim 16 wherein the switch
2 control circuitry comprises a comparator coupled to compare
3 the output of the amplifier to a second reference, an output
4 of the comparator pulsing a divide by two circuit, the output
5 of the divide by two circuit controlling the plurality of
6 switches.

1 18. The charge pump circuit of claim 17 wherein the
2 divide by two circuit is a D flip-flop.

1 19. The charge pump of claim 15 wherein the switches
2 are MOS transistor switches.

1 20. The charge pump of claim 15 wherein the amplifier
2 is a differential amplifier.

1 21. The charge pump of claim 20 further comprising a
2 voltage divider coupled to feed back the output voltage of
3 the charge pump to the differential amplifier.

1 22. The charge pump of claim 15 wherein the reference
2 is a power supply voltage.

1 23. The charge pump of claim 15 wherein the reference
2 is proportional to a power supply voltage.

1 24. The charge pump of claim 15 wherein the output of
2 the charge pump is a level shifted charge pump output.

1 25. A charge pump comprising:
2 first and second flying capacitors;
3 an amplifier;
4 a plurality of switches;

the amplifier being coupled to provide an output responsive to an output voltage of the charge pump; the switches being coupled to alternately switch between:

a) coupling the first flying capacitor between first and second power supply terminals, and coupling the second flying capacitor between the amplifier output and the charge pump output; and,

b) coupling the second flying capacitor between first and second power supply terminals, and coupling the first flying capacitor between the amplifier output and the charge pump output.

26. The charge pump of claim 25 further comprised of switch control circuitry causing the alternating switching before the amplifier reaches saturation.

27. The charge pump of claim 26 wherein the switch control circuitry comprises a comparator coupled to compare the output of the amplifier to a reference, an output of the comparator pulsing a divide by two circuit, the output of the divide by two circuit controlling the plurality of switches.

28. The charge pump circuit of claim 27 wherein the divide by two circuit is a D flip-flop.

1 29. The charge pump of claim 25 wherein the switches
2 are MOS transistor switches.

1 30. The charge pump of claim 25 wherein the amplifier
2 is a differential amplifier having an input coupled to a
3 reference.

1 31. The charge pump of claim 30 further comprising a
2 voltage divider coupled to feed back the output voltage of
3 the charge pump to the differential amplifier.

1 32. The charge pump of claim 30 wherein the reference
2 is a power supply voltage.

1 33. The charge pump of claim 30 wherein the reference
2 is proportional to a power supply voltage.

1 34. The charge pump of claim 25 wherein the output of
2 the charge pump is a level shifted charge pump output.